

Event-IQ

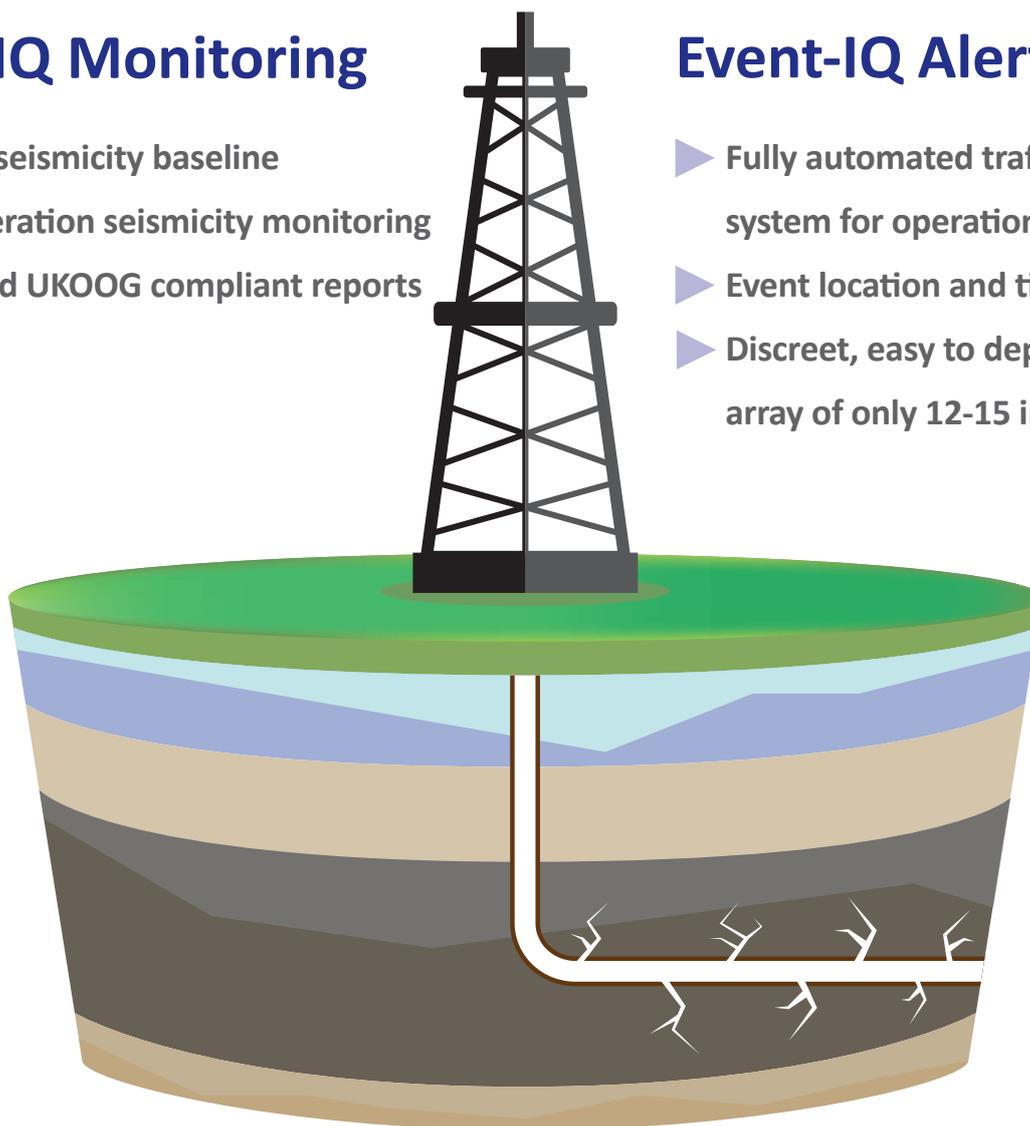
Hydraulic fracturing - UK compliance seismicity monitoring for the life of the well

Event-IQ Monitoring

- ▶ Natural seismicity baseline
- ▶ Post operation seismicity monitoring
- ▶ DECC and UKOOG compliant reports

Event-IQ Alert

- ▶ Fully automated traffic light system for operational wells
- ▶ Event location and time
- ▶ Discreet, easy to deploy surface array of only 12-15 instruments



Event-IQ is a fully integrated solution - the simple way for you to meet compliance requirements for baseline, operational and post operation seismic monitoring.

Choose your preferred level of service from instruments only to a fully managed seismic monitoring solution over the life of the well, including full DECC and UKOOG compliant reporting.

PASSIVE MODE:

Event-IQ Monitoring for baseline and post-operation

Full service Solution

Prior to well operation we establish baseline seismicity characteristics using a surface array of Guralp broadband instruments in the area of the well. The same instruments are left in-situ to record present and post-operation seismicity.

Based on your requirements and the well location, we define the area for survey and the array design in order to meet the required seismicity detection capability. We plan the installation, supply the seismic instrumentation and manage the deployment of the sensors, data collection and processing.

On completion of the pre- and post-operation monitoring we provide you with DECC and UKOOG compliant reports.



Guralp broadband instrumentation is buried near the surface with only the GPS module visible (inset)

THE IMPORTANCE OF BROADBAND

Guralp instruments are true broadband seismometers. True broadband capability is vital to the effective implementation of a traffic light scheme where earthquake magnitudes must be accurately quantified.

Earthquake magnitudes are measured from displacement spectra, as shown in the figure to the right. Only broadband instruments are capable of capturing the full range of displacement spectra, producing a robust estimate of earthquake magnitude.

Industry-standard geophones are limited to high frequencies, resulting in systematic underestimation of magnitudes. Viegas et al. (2012)* show that using data from geophones rather than broadband sensors can lead to measurement errors of as much as 0.6 magnitude units.

Guralp seismic sensors are tried and trusted the world over to deliver high quality broadband seismic data - we have sold over 10,000 instruments to date.

*Viegas G., Baig A., Coulter W., and Urbancic T., 2012: Effective monitoring of reservoir-induced seismicity utilizing integrated surface and downhole seismic networks: First Break 30, 77-81

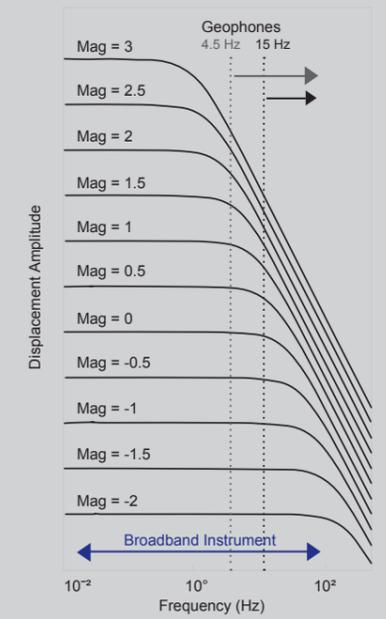


Diagram 2 Comparison showing Guralp broadband instrument and geophone responses

REAL-TIME MODE:

Event-IQ Alert for operational wells

“A Traffic Light System must be capable of detecting events smaller than magnitude 0.0 “ (Green et al., 2012)*

This poses a challenge for conventional seismic arrays, where local cultural noise can prevent such events being detected. Techniques to overcome this have either required shallow borehole arrays or very large (2000 or more) geophone arrays.

A Small Surface Array

The Guralp Event-IQ Alert system is an alternative solution that uses advanced processing techniques to improve signal-to-noise ratios for low magnitude events using a small array of 12 to 15 surface seismometers. This eliminates shallow borehole drilling costs and minimises disruption to the local community.

By applying novel data processing approaches using beamforming-and-stacking, Guralp can detect events that are below the noise thresholds on individual sensors.

Beamforming and Migration to Detect Small-Magnitude Events

Waveforms from individual stations are time-shifted according to expected arrival times, and stacked together, reducing noise levels while boosting coherent signals, allowing an event to be detected.

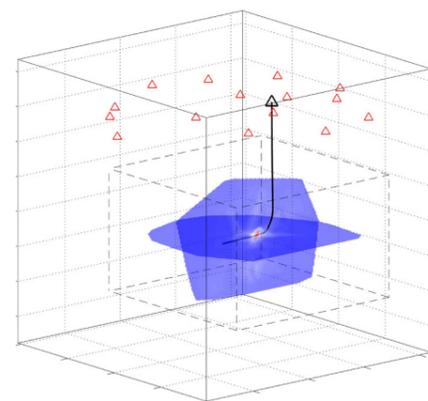


Diagram 1 An example of the Guralp beamforming-and-stacking event detection algorithm. The stack shows a clear and well defined peak marking an event location.

By beamforming and stacking these waveforms, this energy is migrated back to its origin time and position, revealing a clear and well-constrained source such as a seismic event induced by the hydraulic stimulation.

These processing methods are more commonly applied to large arrays used for microseismic monitoring.

Guralp’s Event-IQ technology is modified to produce optimal results using smaller arrays of surface broadband seismometers ensuring that traffic light scheme obligations are met.



MAGNITUDE 0.0 INJECTION PROCEEDS AS PLANNED



MAGNITUDE 0.0 - 0.5 INJECTION PROCEEDS WITH CAUTION



MAGNITUDE 0.5 INJECTION IS SUSPENDED IMMEDIATELY

Diagram 3 Example traffic light monitoring system alerts

Automated Monitoring

Beamforming-and-stacking methods allow for fully automated processing workflows, so ambiguity from manual picking and location of events is reduced.

The array will operate in real-time, providing the operator with immediate warnings if events above or close to traffic light scheme thresholds are detected during hydraulic stimulation. Full reporting to the standards required by DECC and UKOOG will also be provided.

▶▶▶▶ QUICK VIEW:

Event-IQ Monitoring Baseline and post operation

- ▶ Discreet, easy to deploy surface instruments
- ▶ Full service delivery including planning, design, deployment and monitoring
- ▶ Preparation of DECC and UKOOG compliant reports at each stage

Event-IQ Alert Traffic light system for operational wells

- ▶ Requires a small, environmentally sensitive array of only 12 to 15 surface instruments
- ▶ No drilling required
- ▶ Discreet, easy to deploy surface instruments.
- ▶ Full service delivery including planning, design, deployment and automatic alert programming to meet your requirements
- ▶ Full reporting to the standards required by DECC and UKOOG

*Green C.A., Styles P., Baptie B.J., 2012. Preese Hall Shale Gas Fracturing: Review and Recommendations for Seismic Mitigation.

TEST CASE:

Monitoring Hydraulic Stimulation in Oklahoma

An array of 17 Guralp broadband 3TD seismometers were used to monitor a hydraulic fracture stimulation in Oklahoma.

Conventional auto-picking algorithms were used to search for events, finding four events during the monitoring period. We used the Guralp Event-IQ beamforming method to detect smaller events missed by the conventional analysis, as a result we found and located an additional 16 events, a 500% improvement in the number of events detected. The figure to the right shows the mean displacement amplitudes of events detected using both methods.

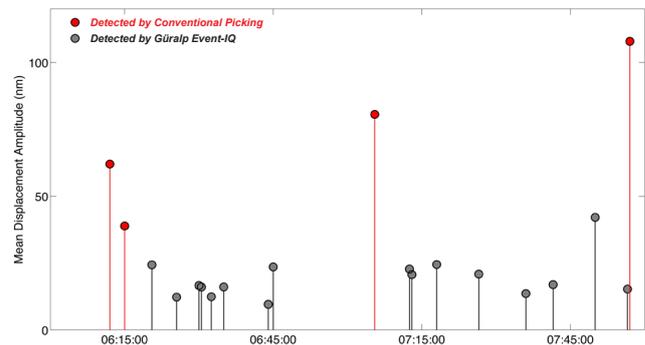


Diagram 4

Mean displacement amplitudes of events detected during trials. The Guralp Event-IQ approach detects smaller events missed by conventional analysis.

ABOUT GÜRALP

Guralp is a leading global provider of advanced seismic monitoring solutions for natural and induced seismological events. Our surface, borehole and ocean bottom systems (OBS) range from very low frequency, very low noise for global seismology to high dynamic range for local strong motion monitoring.

Our products are used in research, civil and industrial applications and are installed in all major ocean basins and across all continents worldwide.

For the Oil and Gas sector we deliver solutions for exploration, production optimisation, risk management and legislative compliance. Our subsea, borehole and land based solutions for conventional and unconventional resources deliver benefits in applications from geohazard assessment and hydraulic fracture characterisation to underground storage and life of field monitoring.

Our services include installation and commissioning; network operation; repair and maintenance services; data processing and interpretation.

Based in Reading, we have been operating for more than 30 years and have established links with a number of UK and international universities and research organisations.



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Guralp instrumentation

Our range of six sensor families can be packaged for deployment at the surface, in boreholes and on ocean floors. Select from analogue instruments and separate digitisers, or integrated packages with a digital output.

Data acquisition equipment can also be integrated or supplied as a separate unit. In addition, we offer installation, configuration, operation and data interpretation accessories.

Borehole Arrays

If borehole monitoring is a requirement, Guralp can deliver slim-line borehole instruments for deployment in shallow (30 – 200m depth, depending on local conditions).

Guralp Flute

A slimline, broadband, three-component borehole seismometer ideally suited for rapid installation.

With an outer diameter of just 51mm, the fully waterproof sensor is available with an optional, single-jaw holelock and can be installed individually or stacked vertically.



Guralp Flute for borehole applications

www.guralp.com